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Perceptual Learning for the Detection of IEDs

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Perceptual Learning to Improve Visual Detection of IEDs

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Background

- The focus of this research is to improve the probability of detection of IEDs using human vision
- According to Atkinson (2007), General Meigs imperative to "Train the Force," has saved innumerable lives -- "soldiers who once spotted few roadside bombs in Iraq now detect more than half before detonation"
- Based on evidence from an analysis of the probability of detection of mines (Staszewski and Davison, 2000), we believe further improvement is possible, specifically, by applying principles of "perceptual learning."

"Perceptual leaning involves relatively long-lasting changes to an organism's perceptual system that improve its ability to respond to its environment" (Goldstone, 1998)

The Soldier or Marine is the best sensor to detect threats (including IEDs) on the battlefield – this project seeks to enhance the performance of this organic sensor.

Scope

- Assess the current state of visual detection training
- Identify potential areas where perceptual learning techniques can potentially positively impact training outcomes
- Determine how to incorporate **perceptual learning** techniques into existing training cycles
  - Define requirements for training aids (to include virtual)
  - Develop a demo program of instruction
- Recommend techniques for assessment of implemented programs

Project Team

NPS Team

- Dr. Michael McCauley
- LTC Jon Alt, USA
- MAJ Jason Caldwell, USA
- MAJ Michael Stinchfield, USA
- Mr. Michael Guerrero, MOVES Research Associate

External Support

- Mr. John Turner, JIEDDO JET
- Mr. Dave Lawson, JIEDDO JCOE

External Partners

- Dr. Grayson Cuqlock-Knapp, ARL
- Dr. Adrienne Raglin, ARL
- Dr. Tom Anderson, ERDC

Alabama Hills, Calif.

Perceptual Learning to Improve Visual Detection of IEDs

Problem statement: To assess the utility of the application of perceptual learning training techniques to improve the visual detection of IEDs.

- Constraints:
  - The study will be limited to the examination of visual detection tasks under the following conditions:
    - Day time operating conditions
    - Operation Enduring Freedom (OEF; Afghanistan) rural terrain types
    - Dismounted with unaided eye
  - The study will use Army and USMC students at the Naval Postgraduate school as Participants, as approved by the NPS IRB

- Assumptions:
  - the findings will generalize to other levels of the stated conditions
  - the population used for developmental testing is representative of the general population on this task

Study Questions 1 & 2

1. *What are the **current methods** used to train visual detection of improvised explosive devices?*
   - Mobile Counter IED Trainer, Institute for Creative Technology
   - ROC-IED, developer
   - Immersive Infantry Trainer – Camp Pendleton; 29 Palms
   - Training lanes
   - Under development: VBSII C-IED Training and JTCOIC

2. *What metrics are appropriate to measure performance on visual detection tasks?*
   - Metrics from signal detection theory (SDT)
     - p(Hit; Miss; False Alarm; Correct Rejection)
     - Receiver Operating Characteristics (ROC curves)

Study Question 3

3. *What are the data requirements for training imagery to improve visual detection performance?*

- Literature indicates that the more **specific** the training stimulus, the greater the increase in performance. Training images should contain representative visual features embedded into realistic complex scenes

- Literature suggests that the **complexity** of the images should be increased over time as performance improves (crawl, walk, run approach)

- No consensus exists on the question "**how many** image are needed? Research data suggest undreds to thousand(s)

- No consensus exists on whether **virtual** images are suitable for training visual detection

Question 3 (Cont.)

- **We found that the images available from SIPR data sources were not well-suited for training purposes.**
  - This issue resulted in a collaborative data collection effort (ARL, JIEDDO JET, ERDC, NVL, JIEDDO JCOE) lead by the NPS/ TRAC- Monterey study team in the Alabama Hills area, near Mt. Whitney and Lone Pine, California

Alabama Hills Data Collection Event, July 2010

- Training and assessment images collected on 26 emplacements
  - Multiple ranges per emplacement
  - Multiple eye-heights
  - Phases of emplacement [early = easy, mid-range, late = difficult]
  - IED types chosen based on current trends in OEF as of June 2010; vetted with JIEDDO JET

- Participation by ARL, JIEDDO JET, ERDC, and NVL
  - Supported by JIEDDO JCOE, NTC

- Resulted in the following images:

  More than 3,200 photos &

  64 dismounted video clips

Study Question 4

4. ***How can the literature on perceptual learning provide insight into the problem of improving performance on the visual detection task?***
   - **Work by McCarly & Wickens on the detection of weapons by airport screeners found that:**
     - Repeated exposures to distinguishing visual features improved detection and recognition performance
     - Conjunctions of features become unitized over time as their association with one another is repeated and reinforced
     - Change-blindness can occur when too much attention is paid to only a certain set of features
     - Pre-attentive processing and attention allocation are improved

Study Question 5

5. What are the software requirements of a laptop- based trainer designed to improve performance on the visual detection task?

- **Basic software functionality must provide visual stimulus to user, track user performance on the detection/identification task, and provide feedback to the user and supervisor**
- **Training tool will be able to be customized with images from particular areas of operations reflecting the tactics, techniques and procedures employed in that region**
- **Feedback should be provided following each trial as well as at the end of each training session, categorized by device type and context/conditions**
- **Feedback to the supervisor will include a summary of the trainees' strengths and weaknesses by device, terrain type, and view point**
- **Developmental testing will inform how instructional strategies may influence the performance objectives.**

Status of Developmental Testing

- **Initial developmental testing of software was conducted with human subjects.**
  - **Institutional review board (IRB) approved the protocols, which were categorized as "greater than minimal risk" due to potential for post traumatic stress disorder (PTSD).**
    - No graphic material is displayed, concerns are due strictly to topic and subject matter
  - **Five Subjects completed; IRB will do a "continuing review"**

- **Next version scheduled to add lesson authoring functionality**
  - **Allow the user to load images from their specific Area of Operation and configure for use in the training tool**
  - **Allow user to specify training images**

Data Collection and Analysis

- ***Detection performance***: **The developmental software captures reaction time, response (location or no target), and provides the data indexed for each image. Data reduction will be further automated in the next version of the training tool.**

- ***Eye-tracking data***: **Eye tracking is employed in the developmental testing. Eye tracking software is calibrated for each subject prior to their participation. This data will help provide insight into how soldiers search complex scenes for IED's. Researchers may provide trainees with instructional feedback based on eye tracking data in future versions of the software.**
  - **Comparison of learner scan pattern or salient features to expert**

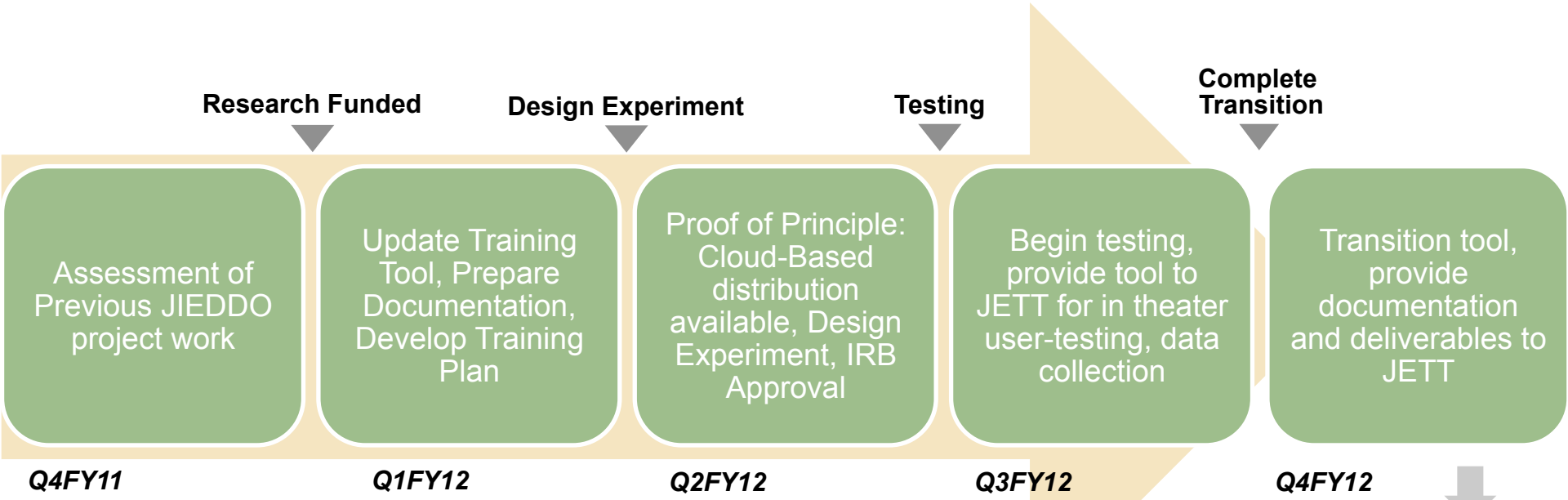
Approach

Build on FY10 JIEDDO-funded work to explore developing proof of principle training packages based on perceptual learning to improve Soldier performance on the task of visually detecting IED indicators.

- Null hypothesis: The PL training program has no effect on hit rate, false alarm rate or sensitivity.
- First Developmental Testing completed with five (5) human subjects in Nov 2010.
- Next software version 2.0 adds additional lesson authoring functionality:
  - Allows the user to load images from their specific area and configure for use in the tool.
  - Allow user to specify training **stimulus.**

- **FY12 JIEDDO project**
  - Improved image database
  - Improved version 2.0 functionality
  - Explore cloud-based distribution of photos and video
  - Operational testing conducting in theater
- **Way Ahead**
  - Submit updated image and video requests
  - Add photos and video to training tool library
  - Write user manual for training tool
  - Document recommended training plan
  - Establish distribution plan ICW JETT.
  - Conduct operational testing of tool.

Timeline and Transition



Research: current operations and previous work.

Review of Current Tool: Document capabilities and limitations for the user and trainers

Version 2.0 Prototype: Improved imagery database, import (photo / video) capability, and usability

Instructional Support Development: User manuals, trainer manuals, and example/ recommended training plans

Transition: Provide tool to JETT for in theater training and assessment. Get Army FA57 community introduced to training tool

- Software documentation
- Recommended distribution plan
- Recommended Training Plans (Instructional Support)
- Proof of principal for cloud-based delivery.
- Experimentation results

Initial recommendation is that the intelligence community should provide the photos for the tool. Army FA57s (Simulations Officers) assist commanders with training plans and distribution of the tool for units

Conclusion

- The application of Perceptual Learning principles to increase the probability of detection of IEDs is a sound hypothesis that requires testing

- Continued development of the prototype training system is needed

  - Development and testing will resume after “green light” is obtained from sponsor (JIEDDO)

  - Next round of development will improve training scenario configuration capabilities (image loading and meta data tagging, assessment and training session authoring) and end of session feedback (provide trainee with score during and after session; saving user profiles)

  - Future work will integrate with virtual trainer (detection while moving; route familiarization; change detection